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Solution mining project at Texasgulf's Cane Creek mine. See p. 32

(photo courtesty Texasgulf Inc.)

Solution Mining Project

by ROBERT L. CURFMAN
Manager, Moab Potash Op
Texasgulf Inc.

Robert L. Curfman joined the Moab potash operations of Texasgulf Inc. in 1963 as field and project engineer. Two years later he became plant engineer and by 1968 had been promoted to mill superintendent. He was appointed to his present position as manager in 1972. Prior to coming to Texasgulf, Curfman was chief engineer at the Moab uranium processing plant of Uranium Reduction Co.

From January 1, 1965 through July 5, 1970, the very difficult potash ore body of Texasgulf Inc. near Moab, Ut. was mined by conventional methods. The mine was gassy, the temperature was high and structural conditions precluded a satisfactory or economical extraction ratio due to the undulating configuration of the ore horizon.

Studies showed potential of solar evaporation

In 1966, 1967 and 1968, alternative mining methods were considered, among which was solution mining of the ore body. Cost studies indicated that the use of crystallizers to evaporate the large amounts of water attendant to solution mining offered no chance of economic success. In 1969 additional testwork and cost studies were carried out utilizing solar evaporation. These studies showed economic potential and justified additional investigation. As a result of these studies, Texasgulf now gathers potash solids from solar evaporation ponds, after pumping them from the underground mine as brine.

The investigations were concentrated in four basic areas: (1) area evaporation rates and crystal growth habits; (2) underground solution tests including heat transfer rates; (3) accelerated evaporation tests to pro-

vide material for metallurgical testing, and (4) tests of evaporation pond lining materials and application techniques, along with area surveys to ascertain if sufficient earth was available in the near vicinity to construct the ponds. The results of the investigations indicated that solution mining utilizing solar evaporation was economically feasible and corporate approval of the conversion project was received in July 1970.

The operation was shutdown on July 5, 1970, and preparation for conversion was commenced on that date.

Mine contains 750 million gal of water

All machinery had to be removed from the mine and the mine made ready to fill the 340 miles of tunnels with approximately 750 million gal of water. For this purpose, a drilling program consisting of 12 holes into predetermined locations in the mined-out workings was started in October 1970 and completed in January 1971. Some of these wells were mine-fill wells, some were vent wells to prevent airlocking, some were water injection wells and one large hole was the brine extraction well, drilled into the lowest level of the workings. Installed in the large hole is an 800-hp deepwell pump for withdrawing brine from the mine.

Engineering and design had to be completed, procurement of materials and equipment started, 400 acres of evaporation ponds (requiring the moving and rearranging of over 2 million cu yd of earth and rock) had to be constructed and lined with impervious membrane to prevent loss of brine, 23 miles of pipelines and 28 pumps totaling over 6000 hp had to be installed before mining could be resumed. With the exception of the pond earthwork and the well drilling, all phases of the conversion were supervised and completed by Texasgulf personnel.

Pond liners cover 400 acres

During the investigation phase, over 50 pond lining materials and combinations were tested prior to selection of polyvinyl chloride as the lining material. The pond linings were necessary as an environmental protection measure to prevent brine from leaking into the Colorado river and to prevent loss of the brine which contains approximately 1.2 lb of potash per gallon. During the pond lining phase, it was necessary to fabricate and install in excess of 2 million sq yd of 20-mil PVC. At that time, this was the largest order which had ever been placed for the material, and fabrication of 400 acres of PVC had never been attempted.

A fabrication shop was set up at the plantsite using leased dielectric seaming machines to fabricate the plastic. Fifty-four railcar loads of plastic in rolls 6 ft wide by 600 ft long were received at the plant and fabricated into panels 30 and 60 ft wide by 600 ft long. The panels were then transported to the pond area, a distance of 3-1/2 miles, and spread in predesigned locations. Field seams were used to make four large lining sections covering the four major pond areas.

Some rather interesting numbers surfaced during fabrication of the liners. There were approximately 590 miles of seams made on the ten dielectric seaming machines which fabricate 30 in. of seam each cycle, or a total of 1,230,000 cycles.

Solution mining method is unique

The solution mining technique used by Texasgulf is unique. It consists of (1) filling the mined-out workings with approximately 750 million gal of fresh water; (2) removal of saturated brine from the mine at a rate to maintain projected production at the same time fresh water is injected at various locations; (3) pumping the mine brine to the solar evaporation ponds, and (4) harvesting the precipitated salt solids, slurrying in recycled, saturated brine and pumping the resultant slurry to the plant for processing through the flotation plant.

The very rough and rolling configuration of the ore body, which made conventional mining very difficult, lends itself to solution mining. The dense, highly saturated brines migrate to the lowest level of the mine, making it necessary to have only one brine extraction well.

The very dry climate and low precipitation in the area is a further plus as yearly evaporating rates are quite high.

Laser beam used on harvesting equipment

Brine from the mine was first pumped into the evaporation ponds on June 30, 1971. The first 6 in. of solids deposited were left on the pond bottoms in order to protect the plastic membrane from mechanical damage by the harvesting equipment. To further guarantee protec-

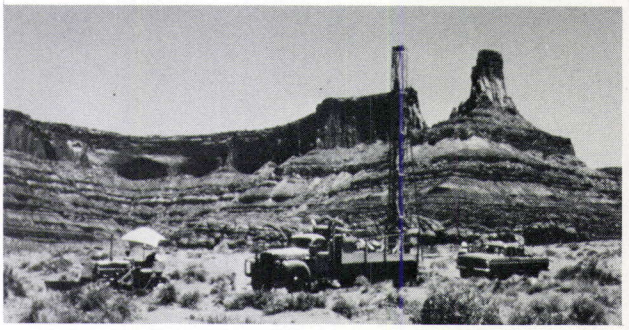
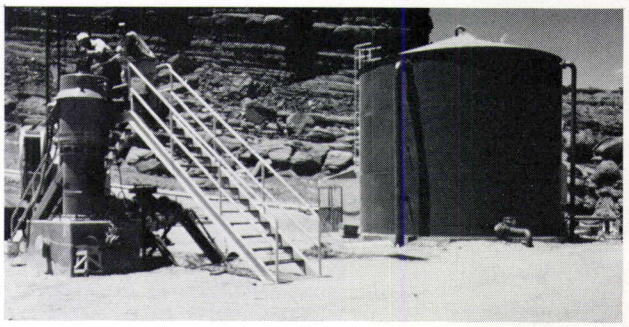
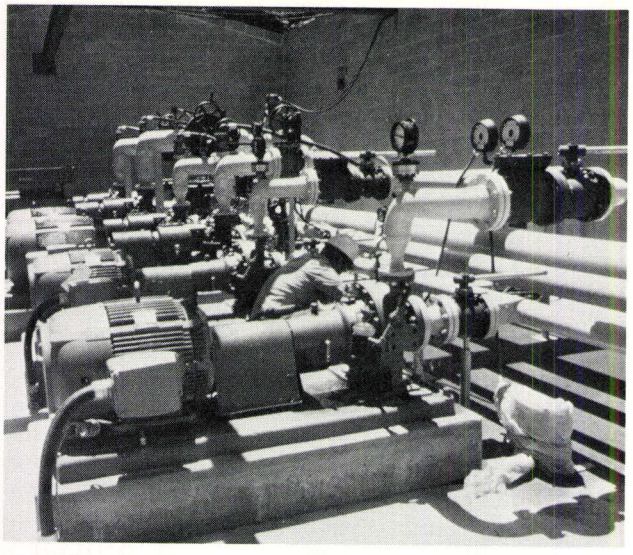


Photo indicates the type of terrain where ponds were built. Drill rig is logging earth cover over underlying rock as part of survey to ascertain if sufficient earth was present in the near vicinity for pond construction



A single 800-hp deepwell pump withdraws brine from the mine. Brine extraction well was drilled into the lowest level of the workings, to where the dense, highly saturated brines migrate

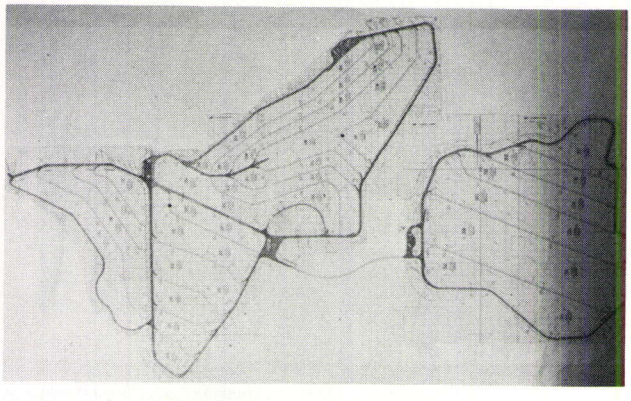


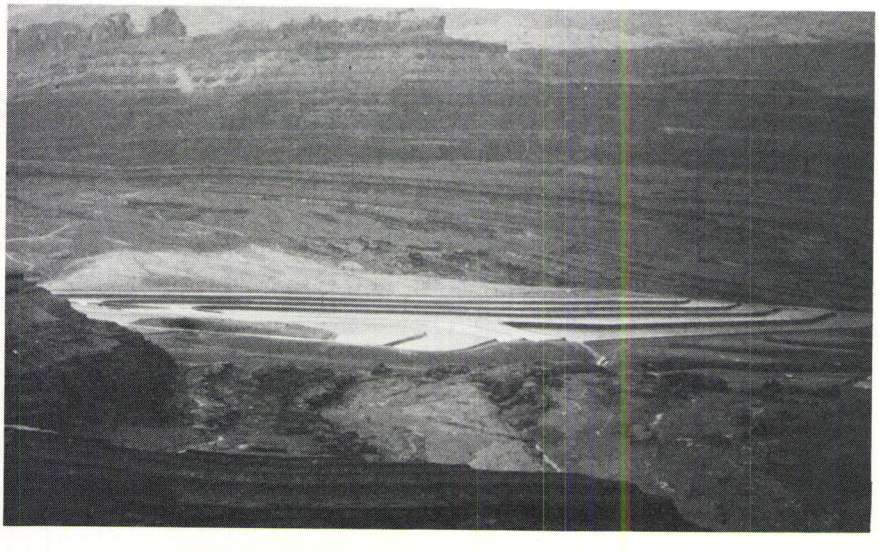
Typical pump station. These are some of the 28 pumps totaling over 6000 hp that were installed for the solution mining project

tion of the membrane, harvesting by the 21 cu yd self-loading scrapers is controlled by a laser beam which controls depth of cut of the machines through electronic control of the hydraulic system. This device prevents harvesting deeper than the limit of the 6-in. base solids in the ponds. Plant startup was on March 1, 1972 and production has continued since that time.

Salable product was dispatched to the storage warehouses on the first day of operation. The processing plant is operated essentially as it was during conventional mining. The crushing plant is no longer needed and a portion of the crystallizer plant is being used on a limited basis only to process tailings and increase recovery. The balance of the plant—conditioning, rougher and cleaner flotation, dewatering and drying, sizing and storage—is the same as was originally constructed. Plant operation has been quite satisfactory and has presented no serious problems.

After more than two years of pumping brine, the mining phase appears to be operating satisfactorily. The extracted brines are being delivered to the surface at temperatures of 91 to 93°F and essentially saturated in the salt components. After the first seven months of operation, the extracted brines showed slight temperature loss and undersaturation. At that time, one point of water injection was changed to a standby well further from





Evaporation ponds covering 400 acres are lined with 20-mil polyvinyl chloride liner material fabricated at the site. Field seams were made with ten dielectric seaming machines that made about 590 miles of liner seams

the extraction point. This change corrected the situation and increased our confidence that the mining phase can be controlled. Daily evaluation of a vast amount of data adds to our knowledge and understanding of the process and we expect this program to continue throughout the life of the project.

Slurry pumping was early problem

We have found that some of the features of the project did not perform as designed or as they appear on paper. The most troublesome problem during startup was pumping of the potassium chloride-sodium chloride slurry from the pond area to the plant, a distance of 3-1/2 miles. Design of the pipelines and pumping system was based on emperical formulae and calculations from our research into other slurry pipelines carrying coal, limestone slurry and other materials. What we did not know was that a mixture of potassium chloride and sodium chloride solids in slurry is quite difficult to pump and requires higher transport velocities than other slurries. There is very little published data covering this particular mixture. The slurry pumping system was extensively revised and today is operating satisfactorily. These revisions include changes in pipeline sizes to adjust velocities and the installation of additional horsepower in the slurry pumping system.

Our experience had shown that 316 stainless steel performed satisfactorily in the brine we had been handling, and it was recommended by the manufacturer as the material of construction for the deepwell brine extraction pump. After 16 months in service, this pump failed and upon pulling exhibited very severe corrosion damage due to the elevated temperature of the brine. The downhole portion of this pump has therefore been replaced with carbon steel column pipe and brine-lubricated, butyl shaft bearings. Costwise, this approach will save considerable money over the long pull even though it must be replaced more often. The new components

Six in. of solids were left on pond bottoms to protect the plastic membrane from mechanical damage by harvesting equipment. Harvesting of deposited solids is achieved with 21-yd self-loading scrapers equipped with laser beams that prevent harvesting deeper than the 6-in. base solids. Pictured are a scraper harvesting in a pond and a scraper dumping into a slurry pit

are designed so no special equipment or expertise is needed to pull the pump and the job can be done by our own people.

Rain hurt production in 1972-1973 winter

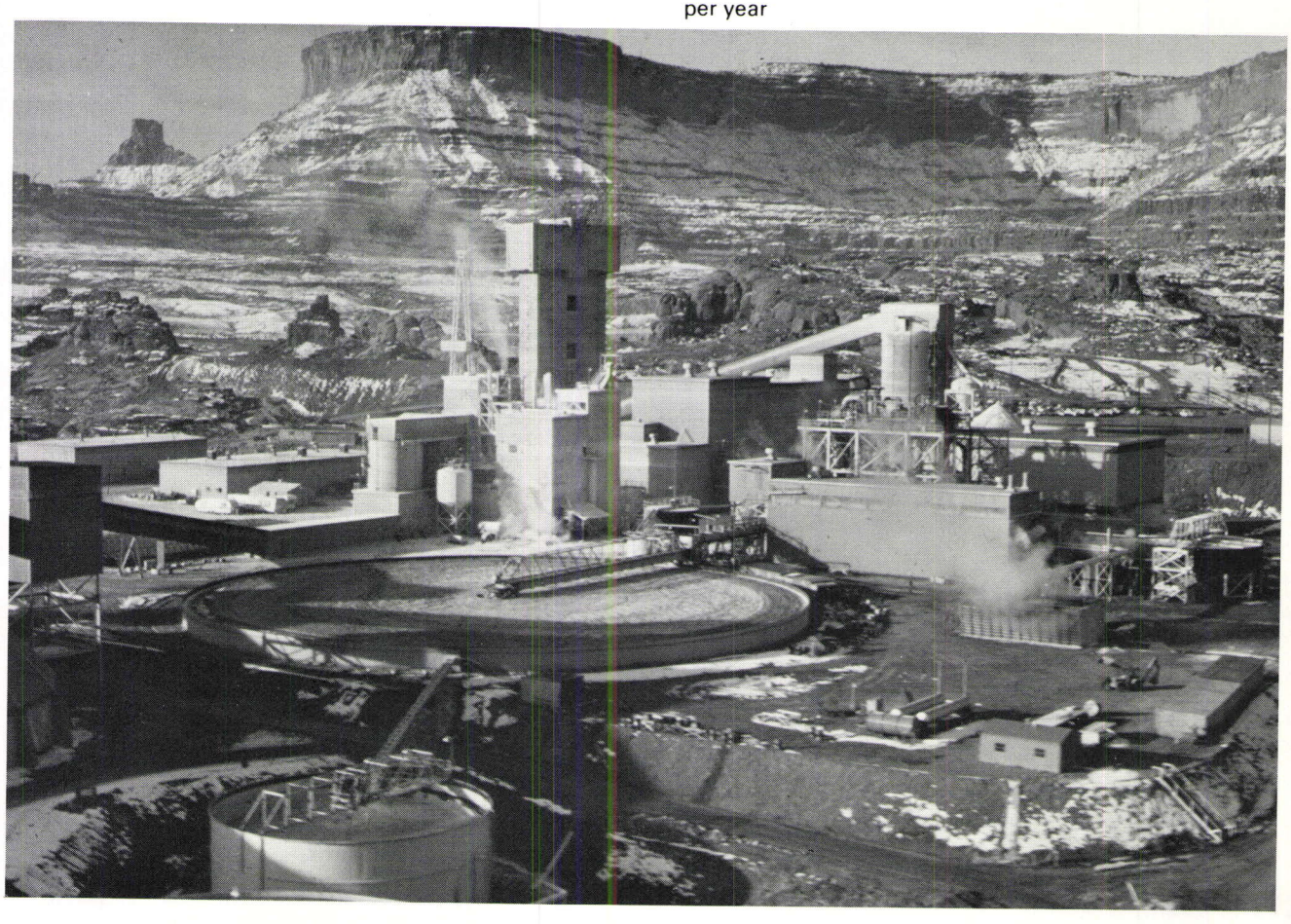
One other problem which we hope is behind us but is beyond our control was that five in. of rain was recorded in the solar pond area in October 1972. This was the first time in recorded history there had been heavy precipitation in the area in October. At the time the ponds carried an optimum burden of brine in preparation for the low evaporation season through February and we had no place to discard spent brine so we could replenish the ponds with mine brine. Due to this, we went through almost the entire winter season with essentially no solids production in the ponds and it was necessary to curtail plant production in January 1973 so pond solids production could catch up. By revising some operating procedures and changing some pipelines and pumping equipment, we feel we have adequately prepared for this situation should it happen again.

Production capability of a solar evaporation operation is a straight-line function with evaporation area available, evaporation rate and brine concentration. With essentially a fixed evaporation area, we have embarked on an extensive test program directed at increasing the evaporation rate of water from brine. The use of brine additives such as radiation-absorbing dyes which also prevent re-radiation hold some promise. Brines of varying depths are being monitored quite closely as this appears to have a decided effect on the evaporation rate. Complete evaluation of this program will perhaps require two or three summer evaporation periods.

Our production is projected at approximately 260,000 tons per year and it now appears that our work force will stabilize at approximately 100 employees, considerably less than the 430 employed when mining conventionally.

As the Texasgulf publication, the *Golden Triangle*, stated in the June–July issue of 1972, there are 100 proud parents at the Moab Potash Operations, proud of the fact that they contributed to the viability of the operation.

The processing plant is operating essentially as it was with conventional mining. Operation has been quite satisfactory and production is projected at about 260,000 tons per year



Texasgulf

Corporate Office
200 Park Avenue
New York, N.Y. 10017

Agricultural Division
P.O. Box 30321
4509 Creedmoor Road
Raleigh, North Carolina 27612

Frasch Sulphur Division
811 Rusk Avenue
Houston, Texas 77002

Moab Potash Operations
P.O. Box 1208
Moab, Utah 84532

Metals Division
P.O. Box 175, Suite 5000
Commerce Court
Toronto, Ontario M5L 1E7

Texasgulf, a diversified natural resources company, is one of the world's largest producers of zinc, silver, sulphur and agricultural fertilizer materials—including phosphatic products and potash. The company is a significant producer of copper, lead and cadmium. Texasgulf is also involved in the production of oil, gas, tin, iron ore and forest products, and in the near future will be a producer of soda ash. To diversify further, Texasgulf is continuing worldwide exploration activities.